U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 55.
L. O. HOWARD, Entomologist.

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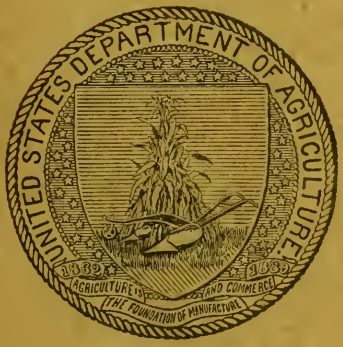
THE REARING OF QUEEN BEES.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST
BY
E. F. PHILLIPS, Ph. D.,
Expert Apiculturist.



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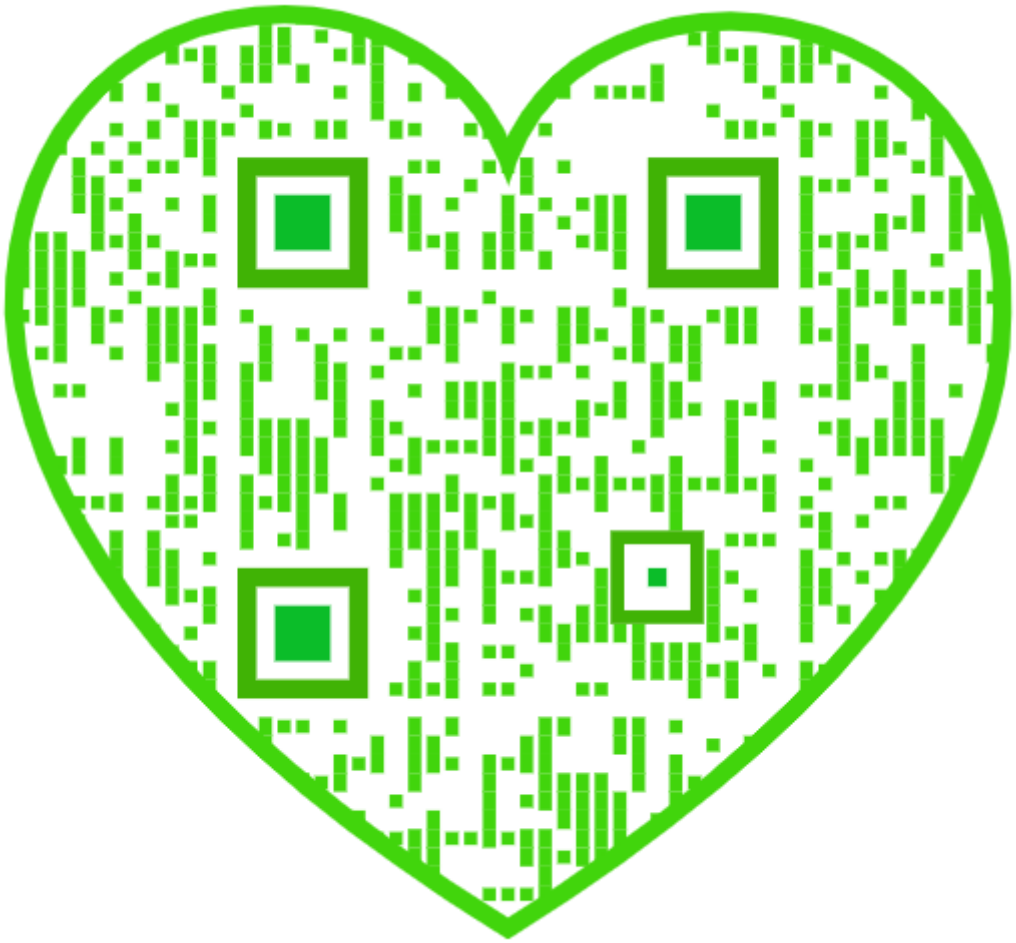

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., October 14, 1905.

Sir: I have the honor to transmit the manuscript of a bulletin on the rearing of queen bees, by Dr. E. F. Phillips, Expert Apiculturist of this Bureau. It is hoped that the explicit directions given in this manuscript governing the production of queens will be of assistance to bee keepers throughout the country, and that it will prove the means of saving money for those who carry on apiculture except in the smallest way. I therefore recommend that this manuscript be published as Bulletin No. 55 of this Bureau.

Respectfully,
L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

Bee keeping is primarily a breeding problem, for the honey surplus of a colony depends so much on the queen. In order to make more public some of the best methods of queen rearing, this bulletin is issued. Much of the labor of manipulation can be avoided by the use of the systems herein described.

It is held by the best bee keepers that it is necessary to restock all colonies with new queens every year; but the practice is not as common as it should be. It is hoped that the simplicity of the methods hereafter described will serve as an inducement to those bee keepers who have not adopted the plan to pursue it in the future.

The rearing of queens has become a separate field, in that some men devote their entire apiaries to this purpose; and to these professional queen breeders must, to a large extent, be given the work of the improvement of stock; but it is far from wise for the ordinary honey producer to neglect this side of the industry.

E. F. P.

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THE REARING OF QUEEN BEES.

NECESSITY OF REQUEENING.

In modern apiculture it is necessary for the bee keeper to be able to get queens at any time. Many bee keepers requeen all their colonies every year; others requeen every two years; it is necessary, then, that they have some method of rearing good queens to use in this way. Even where frequent requeening is not practiced, it is nevertheless often necessary to replace queens which do not come up to the standard in egg laying. Again, it often happens that a colony becomes queenless by the accidental death of the queen. Such a colony, if left to itself, will rear a queen, provided there are young larvæ in the combs, but few bee keepers are now willing to intrust so important a matter to the bees.

Frequent requeening is a very necessary thing if the best results are to be obtained. It is a well-established fact that queens lay more eggs during the first year than in any other, and that the number of eggs laid gradually diminishes until the queen is replaced, because of inability to keep up the colony. Every bee keeper knows, too, that, all other things being equal, the greatest amount of surplus honey is produced by the most populous colony. It is evident, then, that frequent requeening means the maximum honey production.

It has not yet been shown that requeening more than every second year pays for the extra labor, but the best bee keepers hold that queens should not be allowed to live longer than that time. There are, of course, exceptional cases in which the queen will keep up the population of a colony for two or even three years longer than the time given; but unless every colony can be watched constantly it will not pay to risk keeping queens more than two years old.[a]

It is also desirable to have extra queens on hand when the number of colonies in the apiary is to be increased by division or by any of the methods of artificial swarming. If a queen is provided as soon as

[a] An exception to this rule occurs in large queen-rearing apiaries where it is desirable to have large numbers of choice drones always on hand. Since old queens lay a much larger proportion of drone eggs, it is often desirable to keep one or two old queens of select stock on this account. There is no evidence that drones from old queens lack anything in vitality.

the increase is made, the new colony will gain about three weeks in brood production over a colony which has to produce its own queen.

The question which arises in the mind of every bee keeper is: Will it pay me to rear my own queens? Very good untested queens can now be purchased for $1, or even less, it is true; but where a large apiary is to be requeened, this amount, though small for one colony, reaches considerable size when multiplied by a few score; and if this amount can be saved, and the total net receipts of each colony correspondingly increased with comparatively little labor, it would seem folly for the bee keeper to persist in purchasing queens.

It will of course be necessary for the average bee keeper to buy some queens. The selection of fine strains of stock must be left to the professional queen breeder in most cases, and it will be well to buy the breeding stock from some such person. Where no particular improved strain of stock is desired, it may pay the extensive bee keeper to buy an imported queen to be used as a breeder. In the case of Italian bees this does not seem necessary, for very superior stock is reared in the United States, and queen bees of the Italian variety are actually shipped from this country to Italy to be used as breeders. In Carniolan, Cyprian, and other races not so much selection has been carried on in this country, and in consequence the desirability of importations is greater in order to insure purity of stock.

Few bee keepers are so situated that they can with profit rear their own breeding stock. It is the rule in some apiaries to choose the queen from the colony with the best honey record as the breeder for the following year, but this, while seemingly good policy, leads to curious errors. Unless it is certain that the queen is of pure stock or of a fixed cross she should not be used, for it is a well-known fact that when a first cross is used as a breeder the resulting offspring are most variable.

It is the purpose of this bulletin to outline a plan for breeding queens in the home apiary which it is believed can be used with the minimum of labor and expense, one with which good results have already been obtained. Queen rearing can not be carried on without careful attention, but the methods are not, as many believe, so complicated as to make it impossible for the honey producer to afford the time. The beginner in bee keeping can scarcely expect to rear good queens during the first year, and no one can hope to do so until he becomes well acquainted with the habits of bees. It is impossible to give directions minute enough to cover every phase of the subject, and so that every emergency will be foreseen: a great deal must necessarily be left to the common sense and experience of the apiarist. The outline herein given, however, ought to be sufficient for anyone who has had one year's careful work with bees.

NATURAL QUEEN REARING.

Before taking up any artificial methods of queen rearing, it is necessary to have well in mind the circumstances and conditions under which a colony of bees will undertake to rear a queen. It is well known to all bee keepers that workers are female bees, that, when a queen is to be reared, a larva which would under other circumstances become a worker is fed on a specially prepared food, and that thereby the reproductive organs are fully developed. All female larvæ when just hatched from the eggs are alike in development, whether they are destined to become queens or workers. If then any female larva is chosen and so placed that this special food is given it, the resulting bee is a queen; on the other hand if the ordinary larval food is given it, a worker is the result. This discovery is generally attributed to Schirach, although the assertion is frequently made that the fact was known before his time.

Since this change of food is exactly what is brought about in nature by the workers, in order to proceed intelligently, we must first know the conditions under which such a thing can be done; for, while bees are somewhat flexible in their instincts, too great a departure from their natural inclinations will result only in failure. The three conditions under which a colony will rear a queen in nature are (1) swarming, (2) supersedure, and (3) queenlessness.

(1) *Swarming.*—In the spring of the year, as a rule, but at any time when the quarters in which the colony is located are too small, bees acquire what is known as the "swarming impulse." In spite of all the work that has been done on the habits of these insects, just what brings this about and the exact physiological conditions leading up to it, are still unknown. Many weird and wild guesses have been made at various times, but it may be said, almost without fear of contradiction, that we are as far as ever from knowing the true cause of swarming. It does not always hold true that cramped quarters produce the phenomenon, nor that sufficient room will prevent it.

At any rate, when the swarming impulse is aroused the bees begin to build queen cells, and in these eggs are often laid by the queen. The queen cell is larger at its base than the worker cell and projects, when completed, beyond the outside line of the comb, hanging down in an acorn-shaped projection with irregularly pitted walls. The number of such cells which are produced depends on many things, among which may be mentioned temperature and the race of bees. In colonies of Italian bees the number is usually not great, but in Cyprians there are often from 30 to 60 queen cells, while in Tunisians there may be several times that number. When the queens are about ready to emerge from the cells, the old queen and part of the colony leave to establish a new one.

(2) *Supersedure.*—When a queen on account of age or other cause ceases to lay eggs enough to keep up the strength of the colony, the workers build queen cells and rear queens. When the first one of these emerges, an encounter ensues between the young queen and the old one, and almost invariably the latter is killed.

(3) *Queenlessness.*—It may happen that the queen in a colony is killed, and in that case, if there are young larvæ in the combs, the workers will rear queens, one of which later becomes the mother of the colony. While in nature this is probably a more rare condition than is either of the two preceding, it is a normal and natural circumstance under which queens are reared.

In the rearing of queens by the so-called artificial methods it is necessary to follow rather closely one of the three natural conditions. As will be shown later, queens can be reared in colonies with a laying queen, provided a perforated zinc sheet be used to prevent the latter from tearing down the cells, but in such cases we probably approach the swarming condition.

In practice the bee keeper can, if he wishes, take queens from normally constructed cells. By making a colony queenless a considerable number of these will be reared, and by very careful watching almost all of them can be captured and caged before they kill each other or destroy other queen cells. To do this, however, it is necessary to look over the entire colony several times a day for several days, and thus it is far from a time-saving method. The plan is not to be recommended except where it is impossible to use some of the better methods. In the same way queens emerging from cells built in swarming time or during supersedure may be captured. There are, however, better methods of queen rearing; for, by modern appliances, the work is not only made much more simple, but also gives better results. A description of these methods may seem rather complicated to one who has not tried them, but the manipulation is easily learned, and after a brief acquaintance with the appliances the whole subject of queen rearing becomes very simple.

ARTIFICIAL QUEEN REARING.

The methods to be described here are not those of any one system, but are the result of many investigations in this field. It is impossible to give credit to every one who has offered valuable suggestions on this subject, and no such attempt will be made; for it is often difficult to learn with certainty who first used and recommended any particular plan. The bee-keeping journals are full of valuable hints on this work, and methods long ago in use are repeatedly rediscovered and given as new. To prevent any injustice, then, it seems best to avoid giving credit in all cases, except where there is no doubt as to the origin of the plan. The author disclaims all credit of originality in

this bulletin, but can say that all the methods described have been tried successfully by him, either in the apiary of the Bureau of Entomology or before entering the service of that Bureau. The object in writing such a bulletin is that the successful methods may become better known. In most cases the plans given are somewhat modified and are not exactly as used by the originators of the various systems. These modifications may not appear to everybody to be improvements, but they are such as have seemed desirable either in the work of the apiary of the Bureau, or in the experience of other queen breeders. In giving directions for each part of the work of queen rearing, several methods are described; for it is realized that not all bee keepers can conveniently use the same system. Where a particular appliance is known commercially under a certain name, that name is used; for in such cases no dispute as to originality can arise and no injustice can be done. The author disclaims any responsibility in giving these names, but employs those in current use in apicultural literature. None of the appliances which are mentioned in this bulletin are patented and any bee keeper is at liberty to make them, either in the style described or with any modifications which he sees fit to make.

The use of some terms which are rather current in bee-keeping literature has been avoided, since several of the more common terms are not only useless but misleading. If the writers on apiculture were to be more careful in the nomenclature of the science, it would do much toward making their descriptions clear, and at the same time apiculture would be regarded with more respect by beginners and outsiders.

An effort has also been made to exclude all discussion which does not have a direct bearing on queen rearing. It is assumed that the reader is familiar with the principles of bee keeping, and consequently it has not seemed necessary to discuss other phases of the work of the bee keeper.

STARTING QUEEN CELLS.

The queen cells used by various queen breeders vary greatly. Natural queen cells are sometimes used in queen rearing by cutting them from the comb and fastening them with wax to a bar the length of the top bar of the hive. These cells already stocked with royal jelly, the food of the queen larvæ, are ready to use by simply removing the larvæ already in them and replacing them with larvæ from the breeding queen. There are, however, several objections to such cells. They are far from uniform, and are not easily put into nursery cages when sealed; they are supplied with more royal jelly than is necessary; in most cases they are not easily obtained in sufficient number; and, finally, they can not be handled and removed, as can artificial cells. Where such cells are used it is often customary to allow the queens to emerge on the combs of the hive, but this necessitates the hunting for young queens, which is a waste of time.

DESCRIPTION OF CELL CUPS.

It is much better to use a cell base artificially produced. These cells can be made of wax, or on wooden bases with a depression which is filled with wax. They are just as readily accepted by the bees, and because of uniformity and ease of handling are much preferable.

The Doolittle cell, made by molding wax on a stick with rounded end of the exact diameter of a queen cell, is very good and was probably the first artificial cell used in commercial queen rearing. The molding stick is dipped in hot wax, and when one layer of wax is cool, the process is repeated, each time the stick being dipped a shorter distance. The result is a cup with thin edges and heavy base. Such cells are also made by pressing out the wax in a mold. The cells are then fastened to a bar with wax preparatory to introducing the larvæ (see fig. 1).

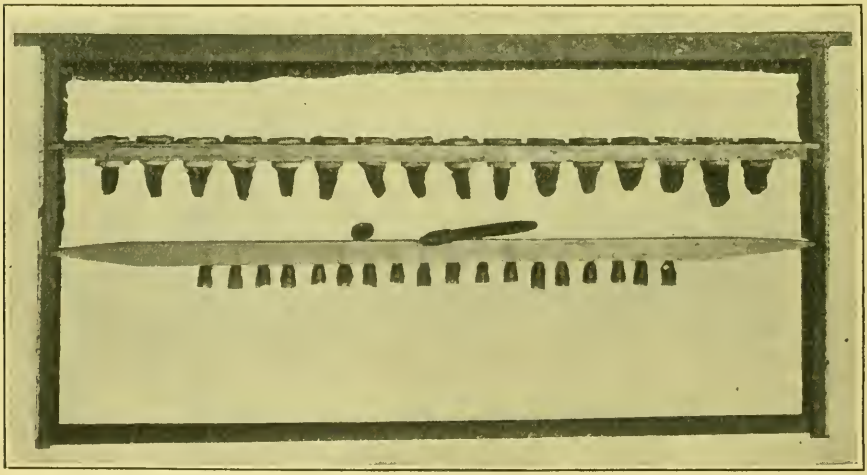

FIG. 1.—Standard frame with bar of completed cells on wooden flanged cups and bar of Doolittle wax cells (original).

Cups with wooden bases are now widely used and have many advantages over the wax cups, in that they can be transferred from one bar to another without danger of breaking and can more readily be used again after the queen has emerged. These cups are usually made of a cylindrical piece of wood with a concave depression in one end which is lined with wax. There is a nail point in one end which allows them to be fastened to a bar by pressure (see fig. 2), or, better, there is a flange at the upper end so that they can be put through holes bored in the bar (see figs. 1 and 2).

TRANSFERRING LARVÆ.

Having procured the cells to be used, with the requisite bars, the bee keeper is ready to transfer larvæ to these cells. Before being

used for the first time, each cell should be thoroughly daubed on the inside with royal jelly. This seems to give to it the odor of a queen cell; at any rate the bees are much more ready to accept it. A small amount of royal jelly should then be put at the bottom of the concave

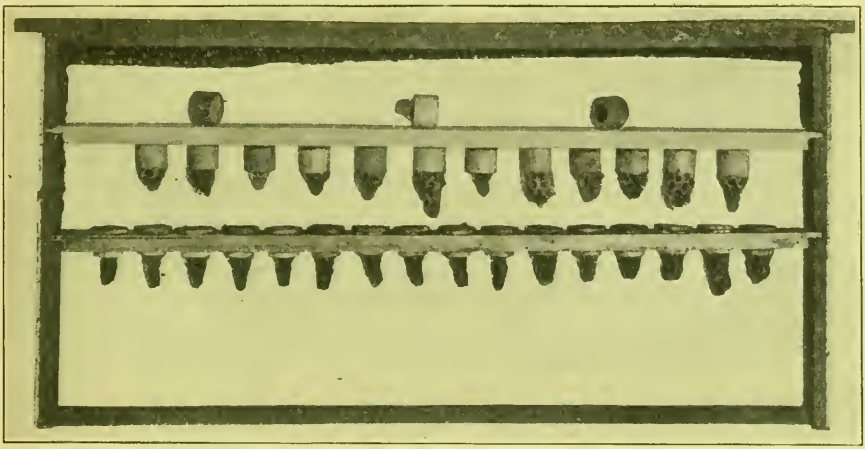

FIG. 2.—Standard frame with bars of queen cells on wooden bases. The top bar holds cells of the Root pattern (original).

depression, and a larva from the colony of the breeding queen placed on it. The larva must not be more than three days old, and it is far better to use one which has not been hatched from the egg for more than one day. This transfer from the worker cell to the artificial queen cell may be done with a match or toothpick which has been cut thin and bent on the end to an angle of about 45°. No special tool is necessary, although when this procedure is to be repeated frequently it may be desirable to use a steel rod or some similar instrument, shaped as above described. The bar is then placed in a queenless colony, and the bees will build down on the cells until they complete them, at the same time feeding the larvæ with royal jelly until the time comes for the cell to be sealed. As a rule not all the cells are accepted, but just as many will be accepted in the case of artificial cells as when natural cells are fastened to a bar, as previously described. If a two-story hive is

FIG. 3.—Two-story hive with perforated zinc honey board between stories, the top to be used for queen rearing (original).

to be used, the bar should be placed in the upper, and the queen confined in the lower, story. For the latter purpose a perforated zinc honey board (see fig. 3) should be used. In a one-story hive the bar should be surrounded by a perforated zinc incubator. A larger proportion of cells are usually accepted in a queenless colony. In case

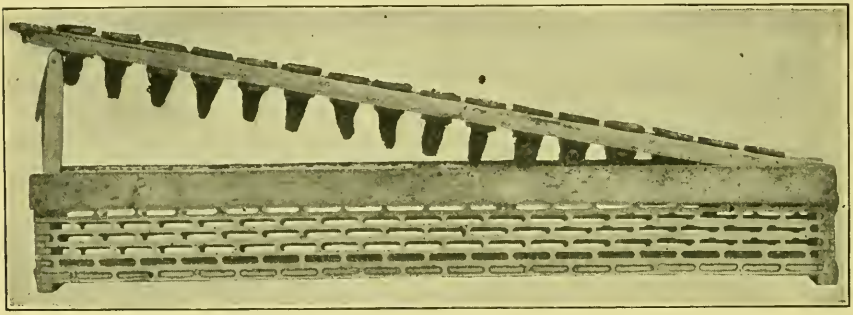

FIG. 4.—"Swarthmore" incubator holding sixteen cells on wooden bases (original).

there is a colony with an old queen which is about to be superseded, a large number of cells may be started, and this is also true in a colony preparing to swarm. Here, too, for safety the queen of the colony should be kept away from the cells by perforated zinc.

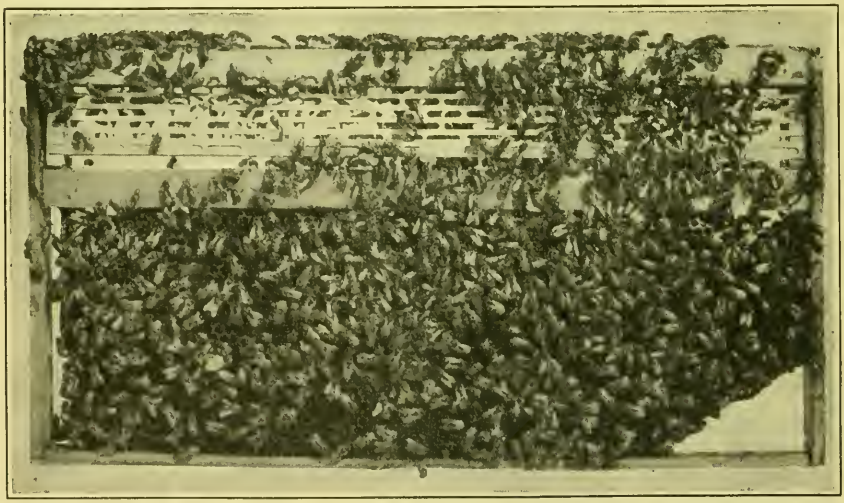

FIG. 5.—"Swarthmore" incubator in frame. The metal supports at the upper ends of the side pieces of the frame do not show (original)

The chief difficulty in rearing queens by this method is to get the cells accepted. Once started, they are usually completed, even if transferred to a colony which does not readily accept cells. In many cases it is customary to start cells in a queenless colony, and in twenty-four hours to transfer the bar to a hive with a queen, putting the cell

in an incubating cage of zinc (see figs. 4 and 5). This gives the advantage of starting the cells under the most favorable conditions for their acceptance, and at the same time makes it unnecessary to have so many queenless colonies in an apiary, which is obviously not economical.

METHOD OF STARTING CELLS.

In starting cells it is desirable that the bar be placed at a level of about 3 inches from the top of the frames when standard-sized frames are used, since this puts the cells in the middle of the brood chamber where the heat is most uniform. This can be done by the method illustrated in figures 1 and 2. After cells are once started they may be kept at almost any level of the hive so long as they are fed and kept warm; and as many as three bars may be fastened in one frame where there are plenty of bees to cover all of them. It is possible to put three such frames of started cells in one story of a colony, but at least one frame of comb should be between each two cell frames, so that there may not be too large an opening in the hive. In this way a strong colony will readily complete and care for more than a hundred cells.

DIFFERENCE IN RACES.

Here, again, racial characteristics play a large part. Italians do not as readily accept and complete large numbers of queen cells as do either Cyprians or Carniolans. In yards in which Italian queens are reared, it may therefore be desirable to keep colonies of Cyprians or Carniolans. It need scarcely be said that in such cases drone traps should be used. No fear need be entertained by the queen breeder that races producing large numbers of queens necessarily produce poor ones. Anyone familiar with the prolificness of the queens of these races could not hold such an idea. There is no evidence that under these circumstances the larvæ are less well fed; indeed in such colonies, as in those with fewer queens to care for, the larvæ always leave some royal jelly in the cells when they enter the pupal stage, during which, of course, no food is eaten.

SWARM BOX.

Since the greatest difficulty with this part of queen rearing is in getting the cells started, it is fortunate that we have a method by which the matter may be made more certain. It is desirable to get bees into the condition in which they will start large numbers of cells; this can be done by the use of what is known as the "swarm box." We know that when bees are in too cramped quarters they acquire the swarming impulse, and that under this influence they begin to rear queens; hence if we confine bees in a hive or box the same condition is brought about, but in a much shorter time. Whether the condition

under confinement is the same as the swarming impulse, we do not know definitely; but, what is more to the purpose, we do know that they accept large numbers of queen cells.

DESCRIPTION OF BOX.

A style of swarm box which has proven very satisfactory in the Department apiary is made large enough to hold five frames of standard Langstroth size (see figs. 6 and 7). The bottom is covered with wire cloth, and small wooden strips, nailed on each end, raise the bottom from the table or floor on which the box rests and thus allow abundant ventilation. The top of the box is removable, and has cut in it two slots, into which are fitted two cell bars. Holes are bored in the latter to accommodate 16 flanged wooden cell bases. These slots, which run almost the entire length of the box, are so placed that if a frame of comb be put on each side of the box and another exactly in the middle, the slots are directly above the intervening spaces. This then places the cell cups directly over the two spaces left in the box.

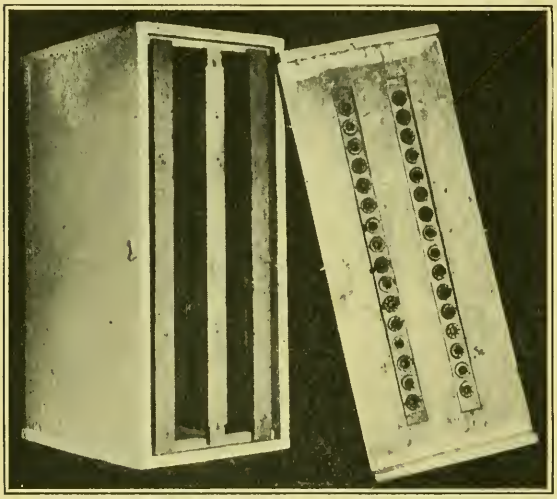

FIG. 6.—Swarm box, showing position of frames and inner side of lid, with wooden cells in place, ready for bees (original).

METHOD OF USE.

In practice, this box is placed on the ground in front of any hive from which a considerable number of bees can be taken. The two side frames are placed in the box, and bees from about six frames of the hive are shaken into it, the middle frame is inserted, and the box is closed. The slots should contain the cell bars and the wooden cells, which are, however, still empty. The frames used in the swarm box must contain honey, pollen, and water, but no brood, and the operator must be absolutely sure that the queen of the colony from which the bees are drawn is not in the swarm box. To allow easy manipulation, the lid of the box should be nailed down or otherwise secured and the box removed to a cellar or other cool place for about six hours. It has been found even better to use only one frame, properly provisioned, in place of three, placing it in the middle of the box; but for

the beginner the use of three frames is recommended. When only one is used more bees should be shaken into the box.

At the end of about six hours the wooden cell bases are removed one at a time, using an extra base as a plug to prevent the escape of any of the bees, and into each base is placed a little royal jelly and a very young larva from the colony of the breeding queen. It is not absolutely necessary to use royal jelly at this time, for if enough of the larval food be transferred from the worker cell with the larva to

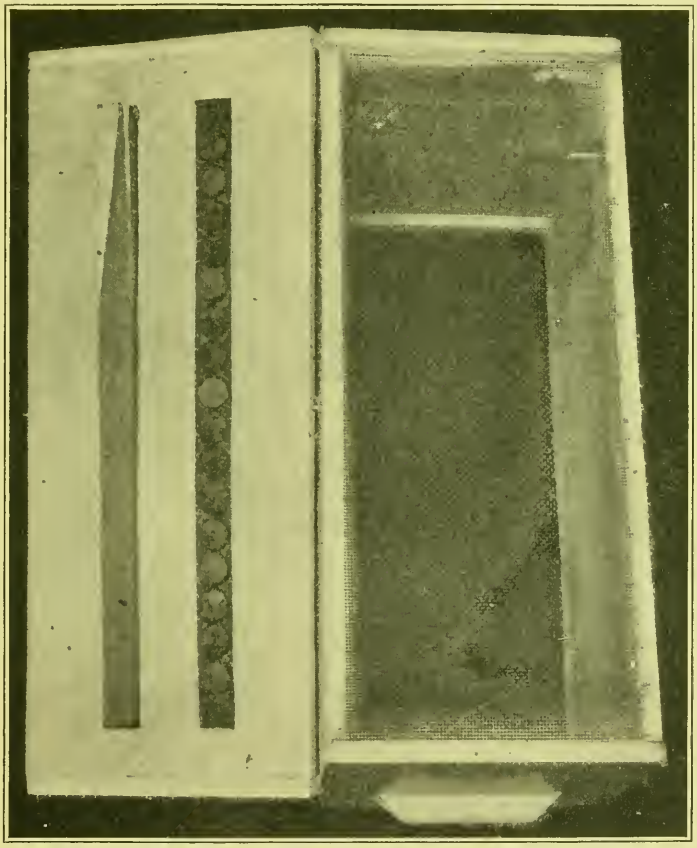

FIG. 7.—Swarm box from below, with top of lid. A blank bar is in place in one slot, as used when only sixteen cells are to be started (original).

keep it moist for a short time, the confined bees will secrete royal jelly so rapidly that the larvæ will neither dry up nor starve. However, in every-day manipulation it may be better to use a very little royal jelly, and the small amount of extra time required for this is, in the hands of most manipulators, generally repaid by the fact that more cells are accepted. The cell bases now containing larvæ having all been replaced, the swarm box is covered with a quilt to keep the cells warm and is put away until the next morning, at which time the box

is opened, the bees shaken out in front of their old hive, and the cells on bars hung in any colony which will complete cells. By this method a much larger proportion of cells will be accepted, and the time required is very small. A schedule, which is in use in the Department apiary during the queen-rearing season, for the use of the swarm box, may not be out of place here to illustrate the small amount of time required for this manipulation, and to be used as a working plan:

9 a. m. Shake bees into swarm box. (About 5 minutes.)
3 p. m. Insert royal jelly and transfer larvæ to cell cups. (About 10–15 minutes.)
9 a. m. (next day). Shake out bees and place cells in colony to be completed. (About 5 minutes.)

While the construction of a special box and this manipulation may seem like an undue amount of labor, the schedule shows that such is not the case. In actual use in the apiary of the Department of Agriculture, it has been found not only to save time, but to be more satisfactory in every other way, particularly in the larger number and more uniform feeding of the cells accepted.

The swarm box has been criticised in various quarters as being opposed to the natural habits of the bees, and it is supposed that this is a valid reason for condemning it. It is a popular fallacy among some bee keepers that there must be absolutely no departure from the natural instincts of the bees, and a new or strange idea is frequently condemned on these false grounds. The same men will use movable frame hives and queen mailing cages, and will remove honey from the hives either by extracting or in the far more unnatural section. We must, as pointed out previously,[a] know the habits of the bees; but equally important in practical work is a knowledge of the amount of flexibility in the instinct. In fact, modern apiculture has come to be a study of the modification of conditions under which bees can thrive to bring about the best results for the bee keeper.

ALLEY SYSTEM OF CELL STARTING.

There is another method of starting queen cells which gives very good results. Mr. Henry Alley recommends that a strip of comb, with young larvæ from the breeding queen, be cut wide enough for one row of complete cells to remain intact. The outer portions of the cells on one side are cut away and every second larva is killed or removed. This strip is then fastened to the bottom of a comb with the open ends pointing downward, and the whole put in any colony used for cell building. The queen cells are built very regularly and a large proportion are accepted. In the apiary of the Bureau it has been found easier to use partly drawn out foundation in which are young larvæ, as shown in figure 8, thus avoiding the cutting away of

[a] *See* "Natural queen rearing," p. 9.

the ends of cells. This method is very simple, since it does away with the necessity for transferring, and gives good results; but the cells must be cut apart to be put in nurseries, and in this manipulation they lack the firmness of cells with wooden bases. It has also been recommended that drone comb be used in the same way, and that a larva be transferred into every other cell. This plan, however, does not possess the one really good feature of the Alley method, and has therefore nothing to commend it.

THE USE OF "COCOONS."

Another plan, used by several queen breeders, is that of transferring the larva in the "cocoon" to an artificial cell cup. The comb is cut down until quite thin (about three-sixteenths inch), and then bent back and forth until the lining of larval skins and the excreta, gener-

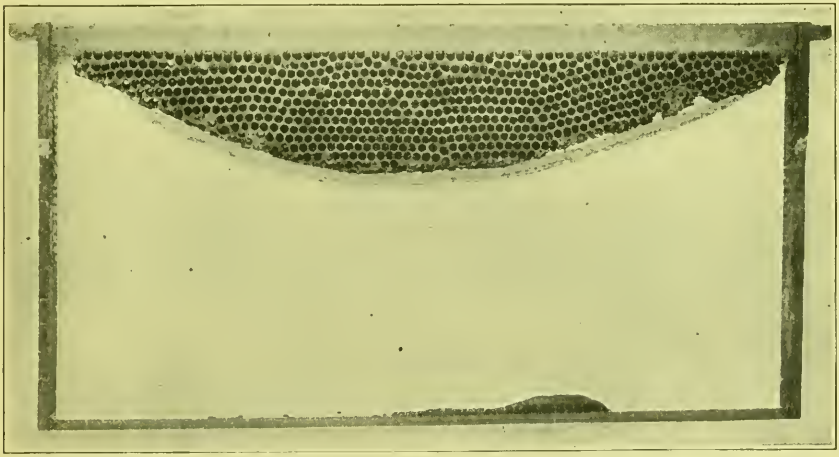

FIG. 8.—Frame with a strip of foundation only partly drawn out, with larvæ in cells, cut according to Alley plan of cell starting (original).

ally called the "cocoon" by bee keepers, is loosened. This is transferred by forceps, or on the end of a rounded stick with a depression in the end. This plan does not require the use of royal jelly; but it takes considerable practice to make the transfer successfully and seems to be no better than the method of transferring larvæ alone.

COMPLETING QUEEN CELLS.

INCUBATORS.

The carrying up of queen cells to the time when the adult virgin queen emerges is much easier than the starting of the cells. Cells once started may be hung in a queenless colony without any covering or protection, and it is an easy matter to have a large number cared for. In the practical work of the Department apiary it is customary

to use cell bars holding sixteen cells each, and two or three of these bars are fastened in one Langstroth frame. Frequently two or even three such frames are put in one hive; but usually part of the cells are sealed or in nurseries, so that there are usually not more than fifty at a time which require feeding. These cells may also be put in any colony with a laying queen, provided an incubating cage of perforated zinc is placed around them (see figs. 4 and 5), or in the second story of a two-story colony, with the queen kept below by a perforated zinc honey board (see fig. 3).

STYLES OF NURSERY CAGES.

One day before the queens are due to emerge, each cell must be placed in an individual nursery, so that the young emerging queens can not attack each other. This nursery may be made of wire cloth

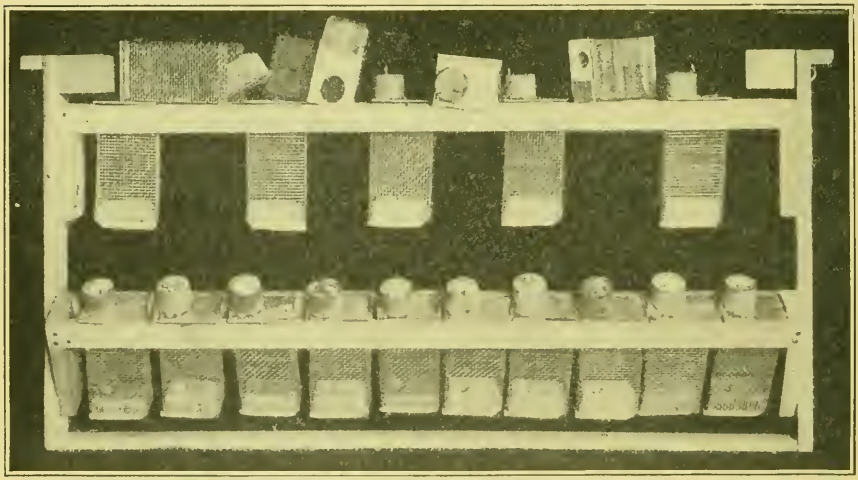

FIG. 9.—Titoff nurseries in frame holder, showing construction of nursery (original).

or of perforated zinc, but wire cloth is perhaps better, since in one or two cases in our apiary, during the past summer, young virgin queens managed to get through the perforated zinc and to do some damage before being discovered. The cell should not be put in a wire-cloth nursery more than one day before the queen is due to emerge, for the workers should be allowed to thin down the wall of the cell so that the queen will have no difficulty in gnawing her way out. Even when separated from the workers by wire cloth for one day, the queen usually takes a longer time in getting out, but no queen which has vitality enough to become a prolific layer will ever entirely fail to do so.

Many different kinds of nursery cages have been advocated, and really there is little choice between them, each queen breeder preferring the one he has used, the choice frequently being made without trying any other. Before making a choice, however, it would be wise

for the prospective queen breeder to study the problem. The ideal nursery cage must at the same time be an introducing cage; so that from the time when the queen cell is put in until the queen is transferred to another hive to be mated, no attention is necessary except to uncover the candy plug to allow the workers to eat the queen out. The Stanley cage, consisting of a cylinder of perforated zinc, will do

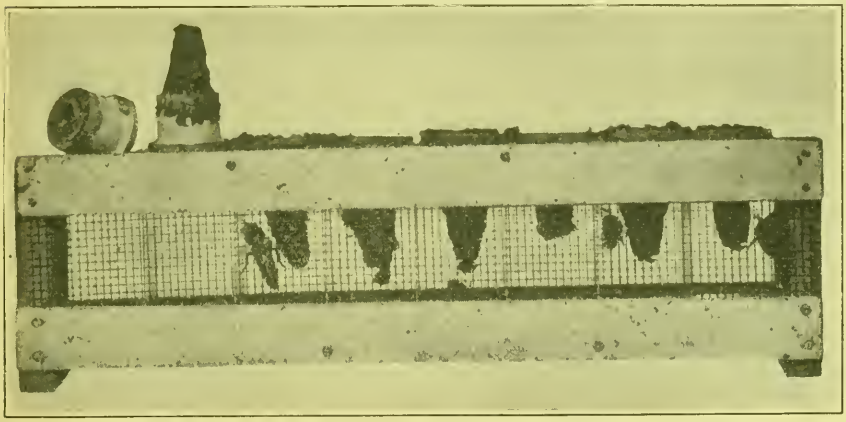

FIG. 10.—"Swarthmore" nursery, with queens. Two cells removed to show construction (original).

very well, provided it is modified so that it can be used as an introducing cage, but it is awkward and not easily handled in a hive. The long West cell protector is also good, except that it is not so convenient for introducing and does not fit into any bar, but must be stuck on a comb. It may also be added that any cell protector is worse than

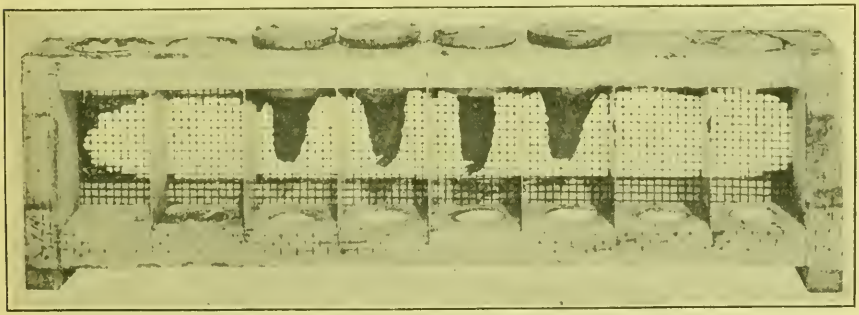

FIG. 11.—"Swarthmore" nursery dissected (original).

useless where artificial cells are used. Where the old method of cutting natural cells from colonies and transferring these cells to queenless colonies is practiced, a cell protector is desirable and almost necessary, since the workers in repairing the cut edges of comb often gnaw entirely into the cell and kill the queen. The author has never known this to happen on artificial cells. The Titoff cage (fig. 9) is also very

good, but has the disadvantage of being awkward to handle in a frame and of being made for use without flanged cell cups. It is a convenient cage for introducing, however.

The Alley nursery, consisting of a block of wood with a large hole bored through it, is excellent. The openings are covered with wire

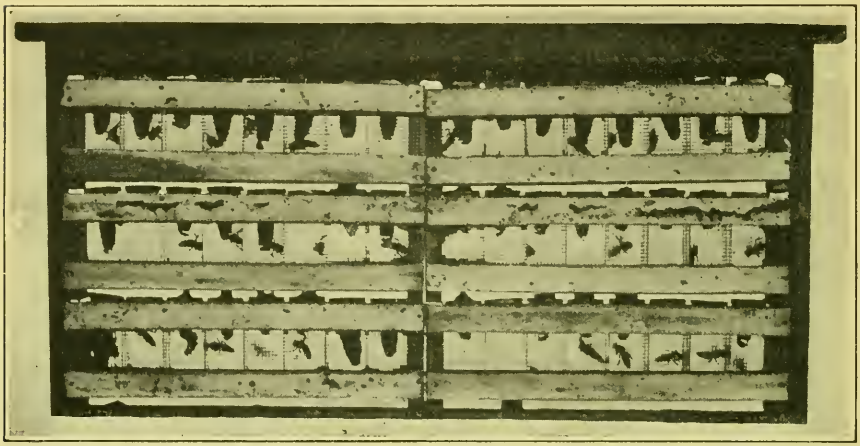

FIG. 12.—"Swarthmore" nurseries in frame, showing method of storing forty-eight queens (original).

cloth, and a hole for the queen cell and one for the candy plug are bored to meet the central hole. It will be found that a cage made with a wooden frame will be better than an all-metal cage, since it is

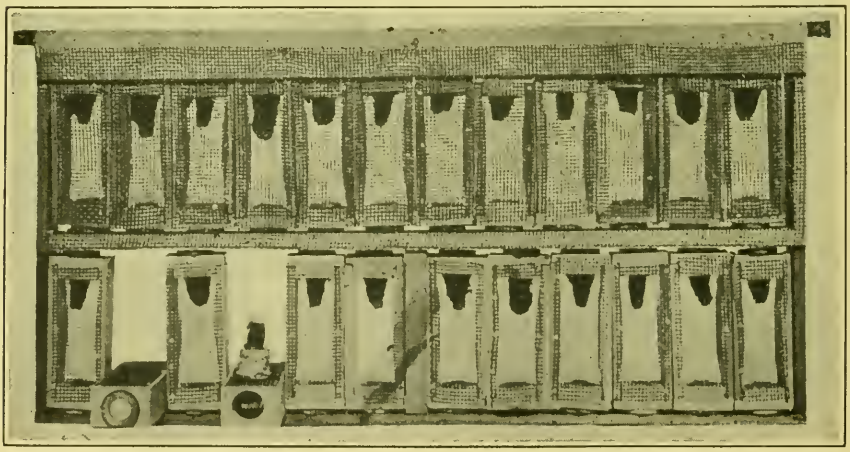

FIG. 13.—A style of cage which answers all the requirements for convenience and usefulness as nursery and introducing cage (original).

more easily placed in the hive in any desired location, and is held in place with propolis. These nurseries can be placed in an empty frame, and left until the frame is filled solid with them; and in this way a colony will keep a good many cells warm until the queens emerge.

The Swarthmore nursery, shown in figures 10, 11, and 12, is excellent also, but it is unfortunate that when this form is used the queens must be removed to introducing cages. This nursery is more valuable when used for keeping queens on hand for some time after mating. Queens can be removed from the mating colonies and stored in them for several weeks even, without any harm; and the mating colony can be used several times in that period for mating other queens. The size of this nursery is very convenient, and 48 queens may be kept in a frame, as shown in figure 12. In the illustration these queens were actually Caucasian virgins, and the nursery had been used for emerging queens. This is not the most convenient nursery for virgin queens, and the author understands that the originator, Mr. E. L. Pratt, does not so use it.

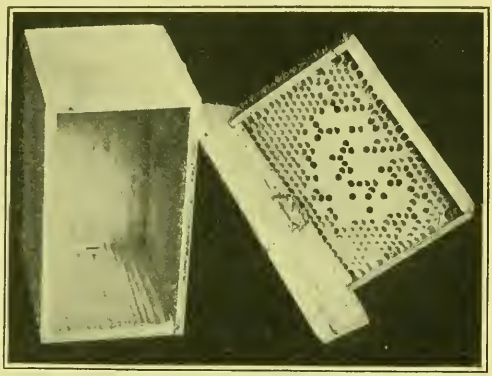

FIG. 14.—"Swarthmore" nucleus with one frame removed to show construction (original).

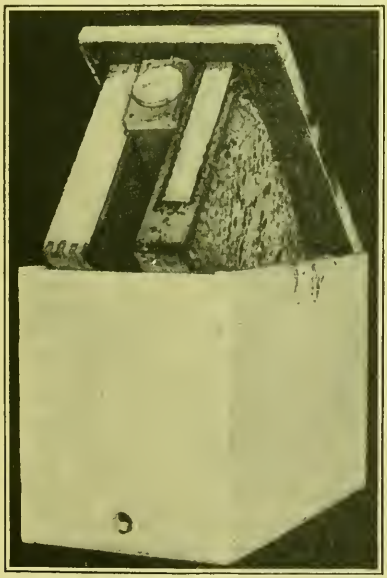

FIG. 15.—"Swarthmore" nucleus with introducing cage (as in fig. 13) in place between the frames (original).

A nursery, then, should be so constructed that the queen will be separated from the workers by wire cloth; should be of such a form that any style of artificial queen cell may be placed in it; should contain a place for candy as food for the young queen; and should above all be useful as an introducing cage. The use of a special introducing cage of any type is not generally recommended. Even in introducing queens received by mail the shipping cage is as good as any "improved" introducing cage and saves time.

INTRODUCING QUEEN CELLS.

But it may be asked, "Why not introduce queen cells directly to the colony where the queen is to stay until mated?" This method is all right where time is no object; but the queens might just as well be kept in a nursery until three to five days old, and thus they need not

be in the mating colony more than four or five days. If a queen cell be placed in a mating colony it means that for a day or two before the queen emerges, and for at least five days before she mates, the colony is unproductive; and commercial queen breeders can not afford such a loss. Such a method of introduction is easier, it is true, but certainly is not economical. In introducing from a nursery it sometimes happens that queens are killed, but even this loss is not great enough to justify the method of introducing cells, especially since queens from cells are sometimes rejected also.

The practice of putting a little honey on the tip of the queen cell when in a nursery, so that the emerging queen may have something to eat while gnawing her way out is not necessary, and has, when practiced, sometimes led to the death of the queen by suffocation.

MATING QUEENS.

The best method of mating queens has perhaps been more discussed by bee keepers than any other phase of queen rearing, the bone of contention being the size of the colony which shall be used in mating.

Some bee keepers insist that queens should be mated only in full colonies, while others go to the opposite extreme and claim that only a handful of bees are necessary to care for a queen during this period of her life.

COMPARISON OF DIFFERENT SIZES OF BOXES.

A comparison of the cost of the two methods will help to solve the difficulty, for bee keeping is a business proposition, and bee keepers desire the most return for the least expenditure of either time or money. Mating in a colony means that that colony is without any new brood for about a week; and since during the summer season the life of the average worker is about six weeks, the loss resulting is about equal to one-sixth the cost of the colony used. This is to some extent made up by the increased activity in brood rearing after such a period of rest; but at any rate a colony can make no increase in size when queens are being mated, and there is almost always a loss. From this standpoint, then, the smaller the colony, the cheaper this part of the rearing will be; and if this were the only point to be considered there could be but one answer to the question.

The time spent in manipulation is an important item, especially where large numbers of queens are to be reared. It is more difficult to introduce a queen into a large colony than into a small one, and this is a factor to be considered, since the chances for occasional losses of queens which may result in considerable loss of time are much reduced by the use of small colonies. In looking over mating colonies to see whether the queen is laying, there is everything to be said in favor of the small colony or "nucleus." There is less comb area to

be covered, and, if any eggs are present, it is easy to see them at a glance; but the chief gain is in the time spent in finding the queen to remove her from the colony. To go over 8 or 10 or even 3 or 4 full frames requires ten times as much time as to open up a small nucleus and pick off the queen almost at the first glance. This much is in favor of small colonies, certainly.

There are, on the other hand, certain disadvantages in the use of very small nuclei in the hands of the inexperienced. Queens can be mated from small boxes with a comb area not greater than that of a 1-pound section of honey, and with a mere handful of bees; but experienced bee keepers have failed to make these work successfully, merely through ignorance of the special manipulation necessary for the smaller colonies. The complaint is also sometimes made that these nuclei are robbed out because the small number of bees will not defend the hive against invaders and that the colony will "swarm out" or leave the box because it is too small. It is also claimed that the nucleus will not be a success unless there is unsealed brood in the comb to hold the bees. All of these general statements are too broad, for such colonies are not more easily robbed than large ones, do not swarm out if properly made, and brood is unnecessary under some circumstances. However, there is a foundation for these complaints, every one of which comes from experienced men.

The entrance to a nucleus of the smallest size should be very small, so that one bee can protect the hive from several robbers. If, by any chance, a small colony without brood becomes queenless, it will almost invariably swarm out, and to this must be attributed most of the cases so reported. Unsealed brood undoubtedly helps to hold the bees in the colony, and certainly should be used in most cases. After the first laying queen is removed from a nucleus, this brood will be present; and from that time on there is no difficulty. To prevent the bees from swarming out with the first queen, brood may be given to them. If, however, the bees are confined in the colony for some time (to which there is no valid objection), they will rarely swarm out, even without brood, and to remove them to an out yard lessens this difficulty still further.

Nuclei with not more than a few dozen bees will mate a queen, and this has been done, and is being done repeatedly. There is objection, however, to the use of the smallest nuclei in the hands of the inexperienced, for they will die out unless watched, and often require restocking. In a large queen-rearing yard, this frequently amounts to considerable labor, and to avoid that feature a somewhat larger nucleus is desirable. Bee keepers are not always adepts at handling small nuclei, and in actual practice a colony should be in such condition that it can be handled quickly, safely, and sometimes even rather roughly.

A size of nucleus which has proven to save both time and labor in the apiary of the Department of Agriculture is one having a comb area somewhat less than one standard Langstroth frame. The hive bodies were originally made large enough to hold five frames, as shown

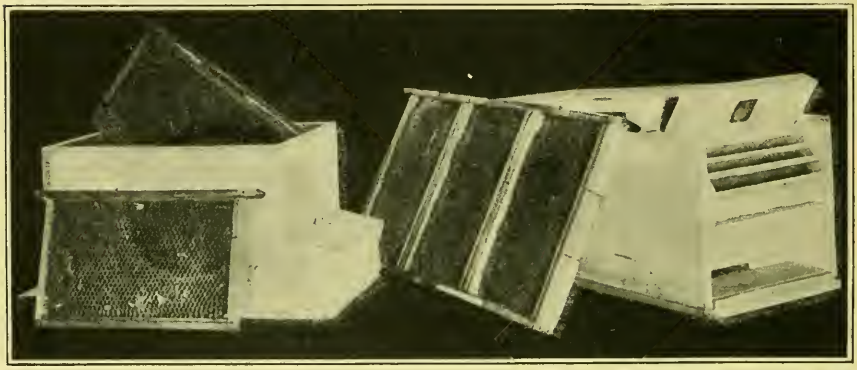

FIG. 16.—Benton mating boxes, showing method of combining frames to make a standard sized frame, and positions of feeders (original).

in figure 16; but, in practice, three or even two are used, and the extra room is an advantage in moving the frames quickly. The construction of the frames is shown better in the illustration than could be done by a written description. Any frame used in a nucleus should be so made that it can be used as part of a standard-sized frame, or so that a number of them fit into an empty frame; for otherwise it is difficult to get them filled with honey and brood before making up the nuclei. The frames of this particular nucleus box are one-third standard size, and two full ones and one only partly built out have given most satisfactory results. If the bees are ready to build, some place should be left for new comb; otherwise they will build small combs to the cover. A feeder is attached either to the back of the hive body, or in front over the entrance, and these can be filled very rapidly when feeding is necessary. A colony of this size requires much less attention in this regard than the smaller size, and is correspondingly better.

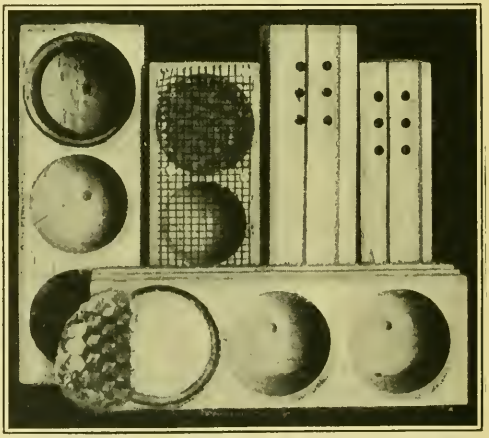

FIG. 17.—Benton mailing cages, showing construction. The larger size is for shipment to distant countries. The smaller cage may be used for shipments to Europe (original).

The comb area is small enough in this hive for the queen to be very quickly found, and, unless too many bees are put in, this part of the manipulation is very simple. The original cost of the hive is considerably more than that of the smallest sized nuclei, but the body is much more durable, and the cost as compared with that of the full-sized hive, which some breeders use, is small. This mating box was designed by Mr. Frank Benton, of the Bureau of Entomology. It is not intended that the inference shall be made that this nucleus box is the best in use. It is described merely as a guide to queen rearers, and any other style of box which combines the good features of this one will do equally well.

No one can deny that queens may be mated in hives smaller than a full colony, but a question sometimes arises as to whether the queens are as vigorous and prolific after being mated from small boxes. To this, it may be answered that the successful mating of a queen depends on the drones which fly in the air; and this is in no way influenced by the size of the hive. It takes very few workers to feed a queen—witness the mailing boxes—and this is the only function of the accompanying bees. If then a queen is herself strong and vigorous, and meets an equally vigorous drone, she will be successfully mated, will be just as prolific, and will lay just as long, when kept in a small colony to mate as in a full-sized one. From a practical standpoint it may be answered that queens mated in small nuclei when put to the test have actually proven as good as those mated under other circumstances. This is after all the true test to be used.

PHENOMENA IN MATING.

In from five to ten days after the emerging of the young queen from the queen cell, she leaves the colony for her mating flight. The first flights of a queen from the hive are very short, and, like young workers, she flies in circles near the entrance, as if fixing the location. Several such flights may be taken before she really takes a long one. Finally, however, she leaves the entrance and flies in ever-increasing circles upward, and, if there are drones in the apiary or near by, she is usually mated. The height to which she flies and the distance from the hive at which she meets the drone depend entirely on circumstances; it may be near at hand or even a couple of miles away. This is a matter very difficult of observation, naturally, but the mating has often been observed by chance. It is a very simple matter to see the first circles of the virgin on leaving the hive entrance, and if drones are plentiful it is not hard to see that many of them start after her. Anyone can verify so much; the rest depends on chance observations.

From dissections of virgins and fertile queens, it has been found that, in mating, the spermatheca or seminal receptacle is filled with spermatozoa or male sex cells. The spermatheca is a very minute sac

opening into the oviduct down which the eggs must pass in going from the ovaries to the outside of the body. As each egg is laid, if it is to be fertilized, it receives one spermatozoon from this spermatheca, and the male cell is received into the egg and unites with it. More than one spermatozoon may adhere to the outside of the egg, but no normal egg will admit more than one through the micropyle or opening in the end of the egg covering.

In mating, the queen receives an enormous number of these spermatozoa, the number having been estimated at from two to twenty million. Since mating usually occurs but once, it is evident that these spermatozoa must be capable of independent existence for five years or more, for they are not capable of dividing or increasing in number in any way, and the queen is of course unable to produce new ones. Frequent cases have been reported of queens which have mated more than once, and this probably accounts for irregularity in the markings of the offspring of some queens. It is claimed by some that obviously the first mating must have been unsuccessful, but there seems to be no ground for that view, and there is no reason to believe that both matings were not complete. There is no reason whatever, so far as is known, why a queen can not receive a supply of spermatozoa from two drones, and some of the arguments to the contrary, with no basis of observation or knowledge of the anatomy, are not worthy of consideration. Cases have even been reported in which queens which have actually begun to lay have gone out for a second mating; but the evidence is as yet meager, and it will be well to wait for further observation before considering such a possibility. Usually, however, a queen takes but one mating flight, and thereafter never again leaves the hive except with a swarm. The ovaries develop to such an extent that flight is impossible, without a previous stoppage in egg laying.

TESTING QUEENS.

If the honey producer is rearing queens for his own use, they may be introduced into full colonies as soon as they begin to lay. A fair idea of the value of the queen may be formed from the number and regularity of the eggs laid in the nucleus box, and if later she is found to be mismated, or not up to the standard in egg laying in a full colony, she should be discarded. A queen may be tested as to the purity of mating by allowing her brood to emerge in a small nucleus, but no estimate can be made in this way concerning her prolificness. In testing for pure mating, however, the entrance should be covered with perforated zinc to prevent the colony from swarming out. If a queen is to be sold as "untested," she may be shipped as soon as she begins to lay after mating. Tested queens are those which have been kept until their progeny show the markings of pure mating.

Tested queens which have been kept in full colonies to observe purity of mating, and which after one season show that they possess ability to produce strong colonies, are sold as "select tested." However, it is to be feared that some queen breeders are not careful enough about this test and that queens are often sold under this guaranty which are simply tested queens one year old, which simply means that their life of usefulness is thereby shorter by one year. For breeding, nothing but the very best of "select tested" queens should be used. Great care should be exercised in choosing such queens by watching purity of mating, prolificness, honey production of workers, disposition of bees, tendency to keep a very large colony of bees at all seasons; and especially, care should be taken that brood rearing does not cease as soon as the honey flow slackens in midsummer. Some bees, otherwise good, will stop brood rearing with the first sign of a decrease in honey, with the result that the colony enters the fall flow with old bees, and that scarcely anything but old bees are in the colony at the beginning of winter. This is probably the essential cause of the excessive death of bees in early spring, known as "spring dwindling."

NECESSITY OF PURE STOCK.

The necessity of purely-mated queens for breeding can not be too emphatically urged. The so-called "hybrids," or mismated queens, produce young queens of so much variability in every character that it is very unwise to use them. There is one phase of queen breeding which would doubtless prove useful, but which has not yet been tried to any extent. The first crosses of various races have proven very useful; as, for example, the cross between Cyprians and Carniolans, but no breeder to the writer's knowledge has ever undertaken to fix the type. That this could be done seems very probable, reasoning from what we know of crosses in other animals, and by careful selection of prolific queens whose workers showed all the characteristics of the first cross, these crosses would doubtless prove valuable as breeders. Under no other circumstances, however, should mismated queens be used.

SELECTION OF DRONES.

The selection of drones is one of the things in which the vast majority of bee keepers are notoriously careless. Queen breeders will select a breeding queen with great care and allow her progeny to mate with drones from any hive in the apiary, and just as long as this is done there can be no advance in the types. Drones should not be allowed to fly except from colonies where the queens are prolific and the bees good workers, and just as much care should be exercised in the choice of colonies for the production of drones as for breeding

queens. The mere fact that mating takes place in the air, out of the control of the bee keeper, is no reason why care should not be taken in the selection of drones which are allowed to fly in the yard. When breeding any race, Italians for example, it is not enough that all the drones be Italians; they should be selected as to honey production of the workers, prolificness of the queen, or any other quality which is considered in choosing a breeding queen.

Selection of drones may be accomplished by the use of drone traps or by cutting out drone comb. For absolute safety the drone trap is preferable, since some drone brood may escape observation. When most colonies are requeened every season, only queens of breeding value should be kept, since old queens produce larger numbers of drones.

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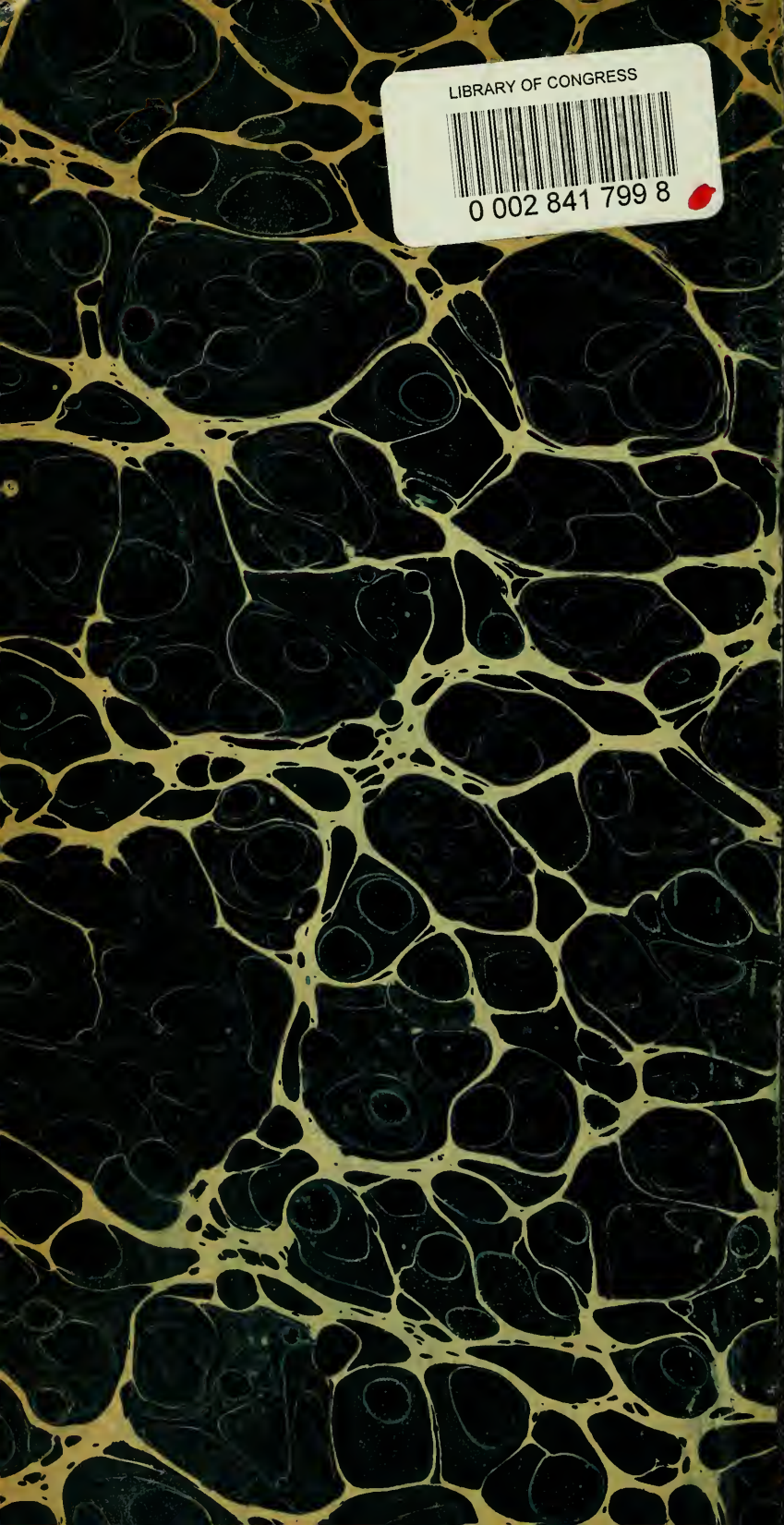
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